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Implementation of a Dual Containment/Surveillance System utilizing scene-change detection and radio frequency technology.

Eric V. Fitzgerald and Richard E. Koenig
Westinghouse Savannah River Company
717-K, WSRC Aiken S.C. 29808

ABSTRACT

This paper will examine the implementation of scene-change detection and radio frequency technology within a Dual Containment / Surveillance (C/S) System. Additionally, this paper will examine the human performance factors in the operation of these systems. Currently, Westinghouse Savannah River Company utilizes the Continuous Item Monitoring and Surveillance System (CIMS) in the performance of Dual C/S to monitor special nuclear materials within International Atomic Energy Agency (IAEA) Safeguards and Domestic Safeguards. CIMS is comprised of the Material Monitoring System (MMS) (R), a multi-media electronic surveillance system developed by Sandia National Laboratory which incorporates the use of active seals commonly called Radio Frequency Tamper Indicating Devices (RFTIDs), NT Vision (R) as developed by Los Alamos National Laboratory, a Microsoft Windows NT (R) based operating system providing for domestic scene-change detection and the Digital Multi-Camera Optical Surveillance System (DMOS) (R) which provides scene-change detection for IAEA. Although this paper will focus on the implementation of Dual C/S utilizing the Continuous Item Monitoring and Surveillance System, the necessity for a thorough review of Safeguards and Security requirements with organizations and personnel having minimal to no prior MPC&A training will also be covered. Successful Dual C/S implementation plans must consider not only system design and failure modes, but must also be accompanied with the appropriate 'mind shift' within operations and technical personnel. This is required to ensure completion of both physical and electronic activities, and system design changes are performed conscientiously and with full awareness of MPC&A requirements.

INTRODUCTION

The Continuous Item Monitoring and Surveillance System (CIMS) was installed to meet the requirements of DOE Order 474.1A, "Control and Accountability of Nuclear Materials" to allow extension of nuclear material storage surveillance periodicity. The CIMS system allows for the performance of Dual Containment / Surveillance (C/S) of the designated stored material within the Westinghouse Savannah River Company. CIMS is comprised of the Material Monitoring System (MMS) (R), a multi-media electronic surveillance system developed by Sandia National Laboratory which incorporates the use of active seals commonly called Radio Frequency Tamper Indicating Devices (RFTIDs), NT Vision (R) as developed by Los Alamos National Laboratory, a Microsoft Windows NT (R) based operating system providing for domestic scene-change detection and the Digital Multi-Camera Optical Surveillance System (DMOS) (R) which provides scene-change detection for IAEA.

This paper outlines the strategy for the implementation of Dual C/S within existing Material Control and Accountability structures, including control, operability and compensatory measures to be implemented during system/component failure, and data archive/retention requirements. In addition, this paper will examine the human performance factors in the operation of theses systems.

IMPLEMENTATION

INCENTIVE:

DOE Order 474.1A currently allows extensions in inventory periods for Material Balance Areas (MBAs) from the nominal semi-annual period to up to a 5 year intervals under combinations of enhanced materials control measures. This allowance within the Order is intended to motivate application of advanced technology to improve overall Material Control and Accounting (MC&A) and reduce exposure of personnel to radiation during physical inventories. Westinghouse Savannah River Companys Nuclear Material Management has completed installation and startup, and placed into operation, the CIMS system in the implementation of Dual Containment / Surveillance (C/S) of the designated stored material.

EQUIPMENT:

Surveillance Systems utilize devices in such a way that each possible diversion path is covered by at least one surveillance device (Single C/S). In a dual C/S system, each diversion path is covered by two surveillance devices that are functionally independent of each other in their Activation Mode (i.e. active tag, optical, etc.). The Westinghouse Savannah River Company has selected and utilizes Active Tag and Optical modes of activation. The Continuous Item Monitoring and Surveillance System (CIMS) and its components (MMS, NT Vision, and DMOS) comprise the Dual C/S System. CIMS is credited within the determination of inventory frequency for the extension to the domestic and international inventory periodicity, for providing remote inventory capability, and is utilized within the performance of Daily Administrative Checks (DAC).

The Active Tag mode of operation is fulfilled by the Material Monitoring System (MMS). MMS is comprised of RFTIDs, transceivers, antennas, data collection and data storage computers, barcode input devices, and a graphical user interface for monitoring the status of material under surveillance. The MMS electronic surveillance system incorporates the use of electronic seals with fiber optic loops referred to as Radio Frequency Tamper Indicating Devices (RFTIDs). RFTIDs provide inventory surveillance of stored shipping packages, and provide real-time tampering indication through the use of a visual display and audible alarms on a centrally located computer work station. The active seal reports the RFTIDs State of Health (SOH) in a user defined periodicity, as well as integrity and environmental condition.

The Optical activation mode of operation is met by the NT Vision system. NT Vision provides a visual record of activities in a defined field of view and is used to monitor movements of material or handling of equipment under surveillance. The NT Vision system monitors scenes and pinpoints additions, removal or changes to the material inventory. During normal operation NT Vision monitors a designated area, referred to as the 'Region of Interest' (ROI), by comparing time dated images. Once the system has established its reference images, changes to those images will cause an alarm and the scene will be recorded. The frequency of recorded images is set as needed for the activities of interest and is set in accordance with the estimated time required for the activities that are intended to be recorded by the system, while these activities are in the field of view of the system. NT Visions image change detection system utilizes multiple cameras, digital image servers, a monitoring computer, and the NT Vision software to monitor the storage facilities. The NT Vision cameras are located as required for complete coverage of the material storage arrays. A NT Vision camera grid identifying camera overlap and coverage of each camera is developed to maximize Dual C/S status. This will allow an alternate or overlapping camera to provide surveillance should a camera fail.

BARRIERS TO IMPLEMENTATION

Common barriers to implementation of Dual C/S include operator interface human reliability errors, a willingness to redefine common definitions and performance requirements, establishment of technical and administrative operability requirements, proceduralization of Dual and Single C/S modes of operation to include compensatory measures for failure of both Single and Dual C/S modes operation, alarm response, and configuration management.

- **HUMAN RELIABILITY ERRORS**
  Implementation of Dual C/S within operational facilities should be recognized as a source of increased operator stress and thus an increase in human errors is likely. Worker stress is likely attributed to a change in mental processes as the worker shifts from physical requirements to mental requirements; from routine to unfamiliar with new and first time task; from manual task completion to computer based task, and from lack of commitment to newly implemented technologies.

- **REDEFINING COMMON DEFINITIONS**
  Implementation of Dual C/S requires a willingness to redefine common definitions. Some of these definitions will require paradigm shifts in implementation methodologies, while other will be new definitions to the operators thought processes. Some new and redefined terms, from an operational point of view, include surveillance, which must be defined and accepted as being inclusive of both physical and electronic inspections, the introduction of unattended and remote monitoring, Electronic Daily Administrative Check, and physical and remote inventory capability.

- **ESTABLISHMENT OF TECHNICAL AND OPERATIONAL PERFORMANCE REQUIREMENTS**
  Consideration must be given to the technical capability and operational requirements of the C/S system to perform its intended function, as is installed and in regards to future upgrades and maintenance.

  The technical capability should be based on the function of the system; selection of equipment with proper sensitivity, tamper resistance, reliability, data quality and authentication; equipment installation and maintainability to intended performance level, frequency of C/S data review; and prevention of false alarms. Additionally, consideration should be given to data storage methods of retrieval and archive, battery life expectance, tamper-indicating protection, remote data acquisition (i.e. State of Health (SOH) monitoring, etc.) automated means [barcode, Personal Digital Assistant (PDA), etc.] of data input, near-real time event notification, Region-of-Interest control over monitored/unmonitored areas of the storage room, video capture rate and image clarity.

  Operability of the CIMS system should be defined for both the Active Tag and Optical systems as well as for the overall joint system capability of dual C/S. System operability requirements should be incorporated for individual component failure as well as system failures. A system component failure does not constitute total system failure or loss of surveillance. Example: a single camera failure vs. a computer failure. Specific attributes of system operability should be inclusive of time lapse recorded image verification, region of interest coverage, and performance testing of the CIMS critical system elements. Performance Test Plans should be developed to identify Critical System Elements. Performance tests should include:

  - Alarm Sensitivity
  - Region of Interest boundaries
  - Change Detection Sensitivity
  - Light/Dark Lighting Changes
  - Active Tag and Optical seal system modes of alarm activation
  - image degradation comparison for each operable camera

DUAL AND SINGLE C/S MODES OF OPERATION TO INCLUDE COMPENSATORY MEASURES FOR FAILURE OF EACH
The Westinghouse Savannah River Company NMM Storage Facility implements the ‘physical and remote inventory’ frequency (extended) when operating under approved single/dual C/S. For material that is not within single/dual C/S coverage due to system maintenance or failure, and therefore not under any electronic surveillance, the ‘physical inventory frequency (reduced)’ shall be implemented. Implementation of Dual C/S, the impact of single system failure (Single C/S) and required compensatory measures is delineated within the following matrix:

CIMS Operability Matrix

NT Vision

MMS

	In Service	Out of Service
In Service	Dual C/S Optimum Inventory Frequency	MMS Single C/S Optimum Inventory Frequency Compensatory Measures Implemented
Out of Service	NT Vision Single / C/S Optimum Inventory Frequency Compensatory Measures Implemented	Manual DACs Reduced Inventory

For SRS NMM storage facility, this means all materials that are not under either single or dual C/S will be subject to physical inventory and measurement per an approved measurement sample plan. In the event of a single system failure, the remaining operating system will be used to perform the electronic DAC by ensuring that no unexplained events since the last DAC have occurred. If an event alarm or a potential malevolent act is detected by either system in single C/S mode, planned compensatory measures will be implemented. Manual DACs will be performed in the event that both systems fail.

Additional consideration should be given to:
Alarm response and responders
RFTID type, design, and frequency and broadcast range

Radio frequency transmitting device security plan
RFTID storage requirement (pre/post programming)
RFTID testing
Destruction methodology of electronic platform Tamper Indicating Devices

CONCLUSION:

Successful Dual C/S implementation plans must consider not only system design and failure modes, but must also be accompanied with the appropriate 'mind shift' within operations and technical personnel. This is required to ensure completion of both physical and electronic activities, and system design changes are performed conscientiously and with full awareness of MPC&A requirements.